hibit in the plainest way the universal presence of a mnemic factor.

We may fix our eyes on phylogeny and regard the living world as a great chain of forms, each of which has learned something of which its predecessors were ignorant; or we may attend rather to ontogeny, where the lessons learned become in part automatic. But we must remember that the distinction between phylogeny and ontogeny is an artificial one, and that routine and acquisition are blended in life.[23]

The great engine of natural selection is taunted nowadays, as it was fifty years ago, with being merely a negative power. I venture to think that the mnemic hypothesis of evolution makes the positive value of natural selection more obvious. If evolution is a process of drilling organisms into habits, the elimination of those that can not learn is an integral part of the process, and is no less real because it is carried out by a self-acting system. It is surely a positive gain to the harmony of the universe that the discordant strings should break. But natural selection does more than this; and just as a trainer insists on his performing dogs accommodating themselves to conditions of increasing complexity, so does natural selection pass on its pupils from one set of conditions to other and more elaborate tests, insisting that they shall endlessly repeat what they have learned and forcing them to learn something new. Natural selection attains in a blind, mechanical way the ends gained by a human breeder; and by an extension of the same metaphor it may be said to have the power of a trainer—of an automatic master with endless patience and all time at his disposal.

Francis Darwin

[23] This subject is dealt with in a very interesting manner in Professor James Ward's forthcoming lectures on the "Realm of Ends." Also in his article on "Mechanism and Morals" in the *Hibbert Journal*, October, 1905, p. 92; and in his article on Psychology in the "Encyclopedia Britannica," 1886, Vol. XX., p. 44.

THE ANALYST, THE CHEMIST AND THE CHEMICAL ENGINEER[1]

Let us consider that the terms, the analyst, the chemist and the chemical engineer, represent those members of the chemical profession who devote their time to the practical and industrial aspects of the science, as contrasted with the teachers of chemistry and the workers in abstract research.

The teacher of chemistry and the man of abstract research may be compared to the exciter, the industrial chemist to the dynamo, which supplies whatever power is to be derived from the science of chemistry, to the industrial world.

It is essential that the industrial chemist and the teacher should work closely together, that each should know the aims and needs of the other, if the power of chemical science is to be developed to its full capacity.

There is no more important member of the community to-day than the chemist. I doubt that there ever were more important members of the community even in the more primitive conditions of society than the men who smelted the iron, and tanned the leather, or the women who wrought and burned the earthen pots and dyed the fibers for weaving. And these technologists were the early representatives of the chemical profession, they were the industrial chemists of those early times—chemists to this extent: they knew the properties of certain substances and the chemical transformations in certain directions which these substances were capable of undergoing.

The soldier, the priest and the medicine

[1] Address delivered before the New Haven meeting of the American Chemical Society.

man were the members of the primitive horde to whom gravitated the honors, the wealth and the positions. But those who worked up natural resources, those who started manufacture, who developed industry and created wealth, were these not in reality the important members of the early community? Were they not in fact the founders of our modern civilization?

The reader of histories of chemistry is impressed at times by the emphasis laid upon the early speculators in chemistry who were all too apt in forming hypotheses. The known facts of chemistry, as shown by their applications in the industries, for some periods, have not been so well investigated and presented—I do not wish to disparage the hypothesis, but it seems as though the history of industrial chemistry had not had its due. When the shadow of the middle ages was lifting, in the fourteenth, fifteenth and sixteenth centuries, and inquisitive physicians and priests and others began to investigate and write on chemical subjects they found in the chemical industries of that time a wealth of material. Through the times of church and military domination, through the period of alchemical investigation and alchemical fraud, the industries appear to have maintained their integrity and on the whole to have handed down traditionally the sure knowledge of those who had gone before, along with additions as additional knowledge was acquired.

There is still a great opportunity for the man who will trace the development of industrial chemistry through all time and show its continuous and logical development. That there was such a continuous development in spite of migration, war, pestilence and theocracy, one must feel certain. The industrial man usually escapes many of the vicissitudes of life except poverty and work. It is easy for priest and soldier to quarrel with the man of strongly expressed ideas and of great self assertion, with the man striving for wealth and power, difficult with the simple manufacturer of raw materials into various commodities. It would not do to say that the manufacturer fared well through all the changing fortunes of ancient and medieval history, but we can well believe that in spite of adverse conditions he maintained his processes, added to them, and transmitted them to his successors by the traditional route.

The chemical technologist, represented by the early workers in chemical industries, preceded the industrial chemist as we know him to-day. Unarmed by systematic knowledge, unversed in the definite methods used to-day in investigating chemical industrial problems, he yet developed chemical industry in some instances to a condition which has not been modified in essential particulars, by the accumulated scientific knowledge of the present time. Consider, for example, the soap industry. The world over, soap is boiled to-day essentially as it was in the sixteen hundreds, before the birth of modern chemistry, two hundred years before the composition of fats was known, two hundred years before the nature of the alkalies or the process of saponification were understood. To-day we recover glycerol and salt, we use more soda and less potash, we are more skilled in the use of fillers in the manufacture, but on the whole the procedure is the same empirical one which has been used for three hundred years. In recent months something has been accomplished by Leimsdörfer in Germany and Mercklen in France, to rescue soap manufacture from empiricism, but the day is yet distant when scientific practise will be substituted for practical experience.

In many chemical industries the same

conditions prevail or prevail to a large extent. Think for a moment of the iron industry and other metallurgical branches, of the glass and particularly the pottery industry, and of other lines, and it is not difficult to see that the chemist has already much work laid out for him. The traditional empirical knowledge of chemical manufacture has always proved a rich field for the chemical investigator and it is as broad and rich and fruitful to-day as ever.

It is the chemist's prominent connection with the industrial life which characterizes our civilization, which gives him the preeminence which he enjoys in our own times. Along with the engineer he is the creator for good or bad of whatever originality there is in our modern life. Contrast his position in the community with that of other scientific men, the zoologist, the geologist, the botanist, and you are impressed with his somewhat closer connection with modern affairs and tendencies than theirs.

As I have stated there is no more important member of the community to-day than the chemist, and I think there is none who feels his importance less. Up to a certain point modesty is a pleasing attribute and desirable, but modesty which through inaction fails to obtain its just reward in position and emolument is scarcely so commendable.

We have heard the broader education of the chemist and the chemical engineer treated of with the fulness and the insight which the subject deserves, by members of the profession who spoke with authority. I want to speak for the broader *life* of the chemist. The broader life in the sense of his coming more in contact with men and affairs and tendencies of the times, of coming to play the important part he should play in the modern world. If I can indicate some of the points of contact, some of the opportunities in America, I shall be satisfied. And first I desire to consider the work of the analyst. The analyst is a chemist who, by various devices called methods of analysis, endeavors to ascertain the composition of substances. The chemical work of all manufacturing plants is mainly analytical and the analyst has come to be a great and important factor in the industrial world.

When one analyst meets another, he usually asks him the question "What method do you use?" and the reply is "I have a method of my own."

I trust that in my remarks I shall not in any way discourage originality among analysts, but I want to direct your attention to some of the consequences of individualism in matters of chemical analysis and suggest a remedy for them.

It will occcur to anybody at once that if a person has a chemical method which is worth applying, he ought convince others of its excellence. Much adverse criticism has been aimed at chemists and chemistry through their failure to deliver agreeing analytical results. A part of the trouble is due to incompetent analysts and a part to unsatisfactory methods and methods which are not uniform. The incompetent man is apparently a necessary evil in every line of work and is difficult to eliminate. Possibly an institute of chemists with strict qualifications would help in this matter. But there is no good reason why we should not have well-tried and uniform methods of analysis.

The reactions on which analytical methods are based are for the most part old and well known. The working out of a method is usually done by a chemist of inventive ability, who is able by various means to make a reaction complete and definite enough so that it will yield quantitative results. We may grant that such work

can not be done by every analyst, but we must admit that every analyst is capable of using an analytical method and also of proving its value or the reverse: otherwise he is not worthy the name of analyst.

The great majority of analytical chemists are not inventors of analytical methods, they are only users of them. Usually when an analyst says: "I use a method of my own," he means that he has perhaps substituted a porcelain for a platinum crucible or one form of burette for another or altered the time of precipitation—in other words, introduced an unimportant variation into a standard method and named it his own. And thus we have in laboratories working in the same line a host of modifications of standard methods, which, while they do not necessarily cause a great difference in analytical results, do introduce a dangerous principle. And in some cases the application of this principle, that every analyst is privileged to modify methods as he chooses, leads to absolutely incorrect methods, as numerous cases which might be cited prove.

The remedy for this state of affairs is the recognition of the principle that no chemist is privileged to use any method or modification of a method which has not the approval of a representative committee of his brother chemists, authoritatively appointed by a chemical society to investigate the method. Further, that when a method is adopted by such a committee, no deviation from it should be allowable in the practise of any individual. In short, we should have standard methods of analysis and adhere to them.

The argument against these ideas will be that we do not want cook-book recipes in place of general analytical methods. If analytical chemistry is to be developed in a scientific way it must be made to yield absolute and not comparative results. There is much justice in these views. They were the views I held for a number of years. But it should be understood that these principles in their application and these general methods in hands less expert than they should be, have brought down upon the heads of chemists much indiscriminate criticism. A merely practical or business man does not have and can not be expected to have any particular insight into chemical methods, nor can he be expected to be able to judge of chemists. So long as he deals with one chemist only, and if this one happens to be a good analyst and to have good judgment, his faith in the profession may remain unchallenged. But if, for the sake of checking results he sends out ten identical samples to ten different chemists and receives ten reports of varying degrees of disagreement, his faith is likely to receive a shock. If he repeats the experiment and fares no better and if he finds that succeeding repetitions do not bring reasonable agreement, he may come to have in time nothing but cynical remarks to make about chemists and the science of chemistry. Of course the inaccurate and inexperienced analyst is a factor in the problem and must be considered, and while other means must be devised to eliminate this factor, as a practical necessity the large chemical societies must take up consistently and determinedly the problem of the unification of methods of analysis. The time has come when no analytical method can be left to individual judgment. Individual differences and individual preferences must be abandoned in favor of the greater good which will come from concerted action and unification in methods of analysis.

Something has already been done in the line I have suggested. The Agricultural Chemists, the Mechanical and Civil Engineers, the Leather Chemists' Association,

the Society for Testing Materials, the National Fertilizer Association and individual firms employing many chemists or operating several laboratories, have done or are doing work along the line of unifying methods. Those whom I have mentioned are not the only ones who are doing this important work, but if they alone were engaged upon it it could fairly be assumed that perfect unification might not result. To be sure, they might not all be working on the same things, but it is certain that much more could be accomplished if the work were being done by one central organization such as our Chemical Society.

There are great advantages in work on unification of methods. It trains the chemist in the art peculiar to chemistry. The work does not require men of great or special talents; on the other hand, it can be done satisfactorily by good careful analysts of ordinary skill and common sense. What it does require before everything else is organization and after this reasonably careful analysts and organized effort. There is no body better able to take up the work in so far as it concerns industrial methods than the Division of Industrial Chemists and Chemical Engineers.

I should say that work of this kind should be considered under eight heads: (1) definitions of all terms requiring definition which come up during the progress of the work; (2) methods of sampling, which, if correct results are to be delivered, are fully as important as correct analyses; (3) uniformity in reporting analyses; (4) methods of analysis themselves—that is methods recommended; (5) other methods which deserve mention but which are not recommended; (6) comments on the methods recommended, possibly detailing the results of a committee's analytical work; (7) publication in convenient and suitable form so that the results may reach all who are interested; (8) provision for a permanent committee to keep the work alive and up to date.

If some such plan as this is carried out, every chemist in the country who is called upon to do analytical work in a given line, will know where to go for approved methods of analysis, and while this will not assure the public, in the absence of capable chemists, of accurate results, it will at least solve a part of the problem. In regard to a distinguishing mark which would guide the public in the selection of competent analysts, possibly a properly organized institute of chemistry would be able to set such a stamp upon a man. But no institute can be considered as worthy of its high calling unless it is organized from among the acknowledged representative leaders of the profession. Mediocre men at the head of an institute of chemistry can do little for the movement which we all must hope will in due season come to pass.

In regard to publication, I suppose there will be some who will say when the work is in full blast—if it ever is—"Nothing in the Journal but methods." But in the first place not all the detailed work need be printed, and if it appears necessary to print a good deal, I can only say that it is important work—as important for the general good of the chemical profession as any research now being conducted. Further, it is not only desirable work, but, as things stand now, it is necessary work, which we can not evade if we would. We as analysts will have to admit that through lack of enterprise or for some other reason we have in some cases, and I am afraid the cases are numerous, allowed the matter of commercial analysis to be forced upon our attention by manufacturers and business men, instead of foreseeing and meeting these demands. Content with discoveries in pure science and in the life within the labora-

tory, we have at times held too much aloof from the needs of the manufacturing and commercial community in which we dwell. The analyst has done much, but we may easily believe that he can do more.

By the unmodified term *chemist* in the industrial sense, we may understand one who does more than analytical work, but who has relatively little to do with construction or industrial operations on the large scale. He may be a consulting man, a research man and an analyst besides these, or in charge of a laboratory employing a number of men. Whatever his particular line of work, there are a number of his class who appear to come in contact too seldom with chemists in other lines, with men of affairs, and with the activities of their community. Their time is spent in their laboratory or in their dwelling. Their lives are, in the familiar phrase, too narrow. There is such a thing as development by indirection, and who shall say that that man is not literally a better chemist who is more active in entirely different lines during a portion of his day? I say this particularly to the younger men who are industriously working their way up in large laboratories—get in touch with business men and methods and with merely practical manufacturers. Such associations lead to new points of view and are most beneficial and suggestive.

The sadly abused term "chemical engineer" may even yet be rescued from disaster and placed where it belongs, describing that adequately trained chemist who is capable of applying chemistry where construction work and operation are required. The chemist who is an engineer has much to answer for, and when I use the term I mean the one who is at least as much a chemist as he is an engineer, and not merely an engineer who, by contact with chemists or laboratories, has picked up a vague idea of chemical methods and problems. Engineering is extremely attractive to the younger chemist on account of its spectacular works and there is a little danger of his over-estimating it as a profession and under-estimating his own. This attitude will easily be outgrown with age, but that it is a factor in diverting men from the serious study of chemistry after leaving the university is unquestionable. Great are the works of the chemical engineer, but even greater the opportunities. I shall try to indicate what I consider some of them.

The chemical engineers have let go and are still letting go many opportunities. They have allowed the civil and the mechanical engineers to appropriate fields peculiarly their own. For example, water and sewage purification, fuels and smoke consumption. They have allowed the engineer, by his greater enterprise, to enter and appropriate to a large extent many kinds of chemical manufacture on the large scale. By chemical manufacture I do not mean the manufacture of chemicals such as acids, alkalies and salts alone, but any manufacture which is based upon chemical change. Many of the very old industries such as ceramics and metallurgy are preeminently chemical industries, but it would seem in many cases as though they were conducted by engineers with the chemist hired as an aid in a minor capacity. And when I make this statement please understand it is not a criticism of the engineer but of the chemist.

There may be some who will say, as I have heard it said, that the problems connected with the lines of work I have mentioned are more of a mechanical than a chemical kind, or at least the chemical problems connected therewith are less difficult of solution than the mechanical. It seems equally foolish to make a claim of

this sort and to answer it, but since the point has come up, a few suggestions may not be out of place. In the purification of sewage, it is true that there are needed well-designed conduits, tanks, filters, holding basins, etc., but it is equally true that the problem is from beginning to end a chemical one, whether precipitation methods or bacterial methods are used. You may say that bacteriology belongs to the biologist, but I think it is true that the problems connected with technical mycology are so largely chemical in nature that the chemist has at least an equal claim to them with the biologist. In bacterial sewage purification, we are not dealing with pure cultures; we supply the proper chemical conditions of oxidation or reduction, of alkalinity, etc., and assume that if the conditions are right the expected reactions under the influence of microorganisms will take place. If any engineer who is not a thorough chemist has a proper conception of the chemistry of sewage purification, I have not heard of him or read his works. I need not say more except that sewage works are usually constructed under the superintendence of engineers who hire analysts to make chemical determinations for them.

The problems connected with fuels and smoke consumption are chemical throughout, and again it is the exceptional engineer who has an adequate understanding of them; yet it can not be denied that the field belongs to the engineer at the present time by right of possession. The problem of smoke consumption was first adequately treated by an engineer and while we say now, glibly enough, that the solution of the problem lies in bringing the gases and solids in the furnace in contact with a sufficient air supply at a sufficiently high temperature, the problem was not so simply stated a few years ago. The problem is solved now at the cost of fire brick frequently renewed, but I am afraid the chemists' contribution to its solution was smaller than it should have been.

In conclusion, I trust that the future will see a closer contact between the votaries of the pure science of chemistry, the teachers of chemistry, the industrial chemists and the community at large. In that union lies the future successful development of the science and profession of chemistry.

W. D. Richardson

PRESENTATION TO PROFESSOR GOLDSCHMIDT

Professor Victor Goldschmidt, of the University of Heidelberg, to-day the foremost crystallographer, was, on his fifty-fifth birthday, presented with a silver punch-bowl by his former students in the United States and Canada. It is doubtful if any teacher of mineralogy either in America or Germany has instructed so many Americans who have since occupied positions of prominence having relation to the geological sciences. The following persons, twenty-five in all, contributed to the gift and signed the letter of birthday felicitation: M. B. Baker, Queens University (Kingston); Dr. Florence Bascom, professor of geology, Bryn Mawr College; Reginald W. Brock, acting director, Geological Survey of Canada; Dr. Hermon C. Cooper, associate professor of chemistry, Syracuse University; Dr. Reginald A. Daly, professor of geology, Massachusetts Institute of Technology; C. W. Dickson, Queen's University; Dr. William E. Ford, Jr., assistant professor of mineralogy, Sheffield Scientific School; Dr. C. H. Gordon, professor of geology, University of Tennessee; Dr. W. F. Hillebrand, U. S. Geological Survey; Dr. Wm. H. Hobbs, professor of geology, University of Michigan; Dr. T. A. Jaggar, Jr., professor of geology, Massachusetts Institute of Technology; Dr. A. C. Lawson, professor of geology and mineralogy, University of California; Dr. E. B. Mathews, professor of mineralogy, Johns Hopkins University; Dr. W. C. Mendenhall, U. S. Geological Survey;